

# SELF-RIVETING MALE FASTENER AND PANEL ASSEMBLY

## FIELD OF THE INVENTION

5

[00001] This invention relates to a self-riveting or self-attaching male fastener and male fastener and panel assembly for high performance applications requiring greater strength and structural integrity, wherein the male fastener, such as a stud or bolt, includes an integral tubular barrel portion which is received through an opening in the panel and riveted to the panel.

10

## BACKGROUND OF THE INVENTION

[00002] U.S. Patent No. 4,459,073 assigned to the assignee of the predecessor in interest of this application discloses an early embodiment of a self-piercing and riveting fastener of the general type disclosed herein and method of installing the male fastener in a panel. As shown in this patent, the male fastener includes a threaded shank portion, a radial flange portion integral with the shank portion and a tubular barrel portion integral with the flange portion and coaxially aligned with the shank portion. The male fastener is installed in a panel by supporting the panel on a die member or "die button" and driving the distal end of the barrel portion against the panel, piercing a slug from the panel and the deforming the distal end of the tubular barrel portion radially outwardly and deforming the panel surrounding the pierced panel opening between the radial flange portion and the L-shape barrel portion. This embodiment of the self-piercing male fastener and method of installation in a panel was not commercially successful because the fastener and panel assembly had insufficient integrity, including pull-out strength and no means was provided to prevent rotation of the stud in the panel. U.S. Patent Nos. 4,915,558 and 5,092,724, also assigned to the assignee of the predecessor in

25

interest of the assignee of this application, discloses a commercially successful self-piercing male fastener and method of installation, wherein the fastener includes a shank portion, a radial flange portion and a tubular barrel portion as described above; however, the tubular barrel portion has an axial length generally equal to the outer diameter of the barrel portion and the male fastener is installed in a die member having a concave die surface, including a frustoconical opening and a concave annular bottom surface joining the frustoconical surface by an annular radial lip. The distal end of the tubular barrel portion is driven against a panel supported on the die member, which pierces a slug from the panel, and the distal end portion of the tubular barrel portion is deformed in the concave annular guide surface into a U-shape, wherein the panel surrounding the pierce panel opening is driven inwardly by the annular radial lip of the die member into the U-shaped barrel portion, tightly packing the panel between the radial flange portion and the U-shaped barrel portion. Although this male fastener and method of installation has been commercially successful, the male fastener and method of assembly is not suitable for high performance applications, such as automotive seat belt retaining studs, wherein the male fastener element must be formed of a high strength steel, or in applications having a panel thickness of greater than about 2 mm. It has been found that the barrel portion will crack when deformed into a U-shape as disclosed in U.S. Patent No. 4,915,558, resulting in poor male fastener and panel assembly integrity.

[00003] High performance applications of this type of fastener also requires improved torque resistance. U.S. Patent No. 6,122,816, assigned to the assignee of this application, discloses a male fastening element of the type disclosed herein, wherein the outer surface of the barrel portion is frustoconical and the radial flange portion includes an outer surface having a plurality of circumferentially arcuate

radially inwardly concave surfaces, improving torque resistance when installed in a panel. In the method of installation disclosed in this patent, the radial flange portion is driven into the panel and the panel is then deformed into the arcuate radially inwardly concave surfaces providing torque resistance. Reference is also made to  
5 copending U.S. application Serial Number 10/271,480 filed October 16, 2002, assigned to the assignee of this application, which discloses a male fastening element of the type disclosed herein, wherein the outer surface of the radial flange portion includes a plurality of circumferentially spaced radially projections or teeth which are driven into the panel during installation and provide greater torque resistance.

10           **[00004]**           However, there remains a need for a self-riveting male fastener or stud of the type described above specifically for high performance applications, wherein the stud is formed of a high strength steel suitable for such applications. The self-riveting male fastener and method of installation of this invention is particularly suitable for high performance applications, wherein the stud is formed of a high  
15 strength steel which avoids cracking of the barrel during installation and may be installed in thicker metal panels as required for safety related applications.

### **SUMMARY OF THE INVENTION**

**[00005]**           The self-attaching or self-riveting male fastener of this  
20 invention is formed of a high strength carbon steel for high performance applications, such as seat retaining studs and other safety related applications, including seat belt retainers, passive restraints and the like. In the preferred embodiments, the self-riveting male fastener is formed of a high strength steel, such as 1038 carbon steel and heat treated to a hardness of at least 30 Rockwell on the C scale or Rockwell C. In a  
25 typical application, the stud will meet Class 10.9, which has a hardness of 32 to 39

Rockwell C. The male fastener may be a stud or bolt fastener, wherein the shank portion may be threaded or unthreaded depending upon the application. One embodiment of the male fastener element of this invention includes a radial flange portion integral with the shank portion and a tubular barrel portion integral with the radial flange portion and coaxially aligned with the shank portion having an open distal end as described above. However, the barrel portion of the male fastener of this invention has an axial length equal to or less than 60% of the outer diameter of the tubular barrel portion. In a preferred embodiment, the tubular barrel portion has a smooth cylindrical outer surface and a smooth cylindrical inner surface, such that the barrel portion has a substantially constant internal and external diameter, except that the internal surface includes a chamfer and the outer surface is arcuate adjacent the distal end of the tubular barrel portion, as is known by those skilled in this art for this type of fastener.

[00006] Many high performance applications also require significant torque resistance. That is, the male fastener must be prevented from rotating in the panel following installation. Although various antirotation means may be utilized, in the disclosed embodiment the outer surface of the radial flanged portion includes a plurality of radially extending circumferentially spaced radial projections or teeth each having a cylindrical outer surface and a planar surface extending generally perpendicular to the circumference of the outer surface of the radial flange portion. Depending upon the application of the of the male fastener element, the male fastener element provides torque resistance to turning in either direction. For example, the shank portion may be threaded and a nut may be torqued on to the threaded shank portion, requiring torque resistance in the direction of rotation of the nut as the nut is threaded or cross-threaded onto the shank portion. However, the nut may also be

unthreaded from the shank for repair or maintenance, requiring torque resistance in the opposite direction. Thus, in the disclosed embodiment, each of the circumferentially spaced radially teeth include planar surfaces on both sides of the radial projections.

5           **[00007]**       The male fastener element is installed in a panel by piercing or pre-forming an opening in the panel having a diameter generally equal to the outer diameter of the tubular barrel portion and supporting the panel on a die member or "die button" in a die press, generally the lower die platen as will be understood by those skilled in this art. However, because the barrel portion of the male fastener is  
10 shorter than a conventional male fastener of this type, the die opening is relatively shallow compared to a conventional die button for this type of installation. The die button preferably includes a concave annular surface which extends to the panel support surface and a central planar nose portion. The male fastener may be received in a conventional installation head attached to the upper die shoe of the die press  
15 which aligns the tubular barrel portion with the opening through the panel and the opening through the panel is coaxially aligned with the central nose portion. The installation head includes a reciprocating plunger which engages an annular surface of the radial flange portion and drives the male fastener toward the panel upon closing of the die press. The distal open end of the barrel portion is then driven by the plunger  
20 through the panel opening into the concave annular die surface of the die button, deforming the panel radially outwardly and the radial flange portion is driven into the panel forming an L-shaped panel portion surrounding the panel opening including a portion extending perpendicular to the planar panel having an internal surface which is deformed against the outer surface of the radial flange portion and a generally  
25 radially inwardly extending portion which is deformed between the radially outwardly

extending distal end portion of the barrel portion, securely retaining the male fastener element in the panel. Where the outer surface of the radial flange portion includes circumferentially spaced radial teeth, as described above, the panel is deformed between the teeth, providing excellent torque resistance.

5           **[00008]**       The male fastener and panel assembly of this invention thus includes a male fastener preferably formed of a high strength steel as described, including a shank portion, a radial flange portion integral with the shank portion having a diameter greater than the shank portion and a tubular barrel portion coaxially aligned with the shank portion having a tubular portion integral with the flange  
10   portion and a generally radially outwardly extending distal end portion spaced from the flange portion, generally perpendicular to the tubular portion. The metal panel includes a planar portion surrounding the outer surface of the flange portion and an L-shaped portion including a portion extending perpendicular to the planar portion having an inner surface deformed against the outer surface of the radial flange portion  
15   preferably in substantially face to face contact therewith and a radially inwardly directed portion deformed between the radial flange portion and the generally radially outwardly extending distal end portion of the barrel portion. Where the outer surface of the radial flange portion includes a plurality of circumferentially spaced radial teeth as described above, the inner surface of the L-shaped panel portion is deformed  
20   radially inwardly between the teeth substantially filling the space between the teeth and provided improved toward resistance. In fact, testing has established that the shank portion will break before rotation of the stud relative to the panel.

**[00009]**       In the disclosed embodiment, the radially inwardly extending panel portion received between the generally radially outwardly extending distal end  
25   portion of the barrel portion and the flange portion is generally rectangular in shape

having a width equal to about one half the width of the planar panel portions surrounding the radial flange portion. The inner surface of the tubular barrel portion formed by the concave annular die surface is arcuate and smoothly blends with the L-shaped panel portion providing a smooth continuous arcuate surface extending from the bottom surface of the radial flange portion to the outer distal end of the generally radially outwardly extending distal end portion of the barrel portion.

[00010] As set forth above, the self-riveting male fastener of this invention is formed of a high strength carbon steel, preferably having a hardness of greater than 30 Rockwell C or between 30 and 40 Rockwell C, for high performance applications, including safety related applications. However, where the barrel portion of the male fastener element has an axial length greater than about 60% of the outer diameter of the outside diameter of the barrel portion and the barrel portion is deformed into a U-shape as shown in the above referenced U.S. Patent No. 5,092,724, the barrel portion will crack when formed of a high strength carbon steel having a hardness greater than 30 Rockwell C. In the preferred embodiment, the axial length of the barrel portion is about 55% of the outside diameter, whereas the axial length of the male fastener disclosed in the above referenced U.S. Patent No. 5,092,724 is about 80% of the outside diameter or greater.

[00011] Other advantages and meritorious features of the male fastener and male fastener and panel assembly of this invention will be more fully understood from the following description of the preferred embodiments, the appended claims and the drawings, a brief description of which follows.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[00012] Figure 1 is an elevated side view of one embodiment of the self-riveting male fastener of this disclosure;

[00013] Figure 2 is a side cross-sectional view of the male fastener  
5 shown in Figure 1;

[00014] Figure 3 is a side view of the male fastener shown in Figures 1 and 2;

[00015] Figure 4 is an end view of the male fastener shown in Figures 1 to 3;

10 [00016] Figure 5 is a side view of a die button which may be utilized in the installation of the male fastener shown in Figures 1 to 4 in a panel;

[00017] Figure 6 is a partial side cross-sectioned view of the die button shown in Figure 5 as indicated by the reference 6 in Figure 5;

[00018] Figure 7 is a partial cross-sectioned side view of an installation  
15 apparatus, including the die button shown in Figures 5 and 6 for installing the male fastener shown in Figures 1 to 4 in a panel;

[00019] Figure 8 is a partially cross-sectioned side view of the installation apparatus shown in Figure 7 during installation of the self-riveting male fastener;

20 [00020] Figure 9 is a side partially cross-sectioned view of the male fastener and installation apparatus shown in Figure 7 and 8 following installation of the male fastener in a panel; and

[00021] Figure 10 is a side partially cross-sectioned view of the male fastener and panel assembly of this invention following installation.



## **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[00022] As will be understood by those skilled in this art and discussed further below, the drawings illustrate only one preferred embodiment of the self-riveting male fastener and male fastener and panel assembly of this invention for illustrative purposes only. The embodiment of the self-riveting male fastener **20** illustrated in Figures 1-4 includes a shank portion **22**, which may be externally threaded as shown at **24**, a radial flange portion **26** integral with the shank portion **22** having a diameter greater than the shank portion **22** and a tubular barrel portion **28** integral with the radial flange portion **26**. As shown in Figure 2, the tubular barrel portion **28** is coaxially aligned with the radial flange portion **26** and the shank portion **22** relative to the longitudinal axis "A" of the self-riveting male fastener **20**.

[00023] The tubular barrel portion **28** preferably has a cylindrical outer surface **30**, a bottom wall **32** and a cylindrical inner surface **34**, such that the tubular barrel portion has a substantially constant cross-sectional area beginning with the bottom wall **32** to adjacent the distal open end **40**. In the disclosed embodiment, the distal end **40** of the barrel portion **28** includes an arcuate outer surface **36** and a chamfered inner surface **38**. The tubular barrel portion has an axial length "L" measured from the annular surface **42** of the radial flange portion **26** adjacent the tubular barrel portion **28** and an outer diameter "D" of the cylindrical outer surface **30**. As set forth above, the dimensional relation between the length "L" and the outer diameter "D" of the tubular barrel portion **28** is critical to avoid cracking of the barrel portion during installation in a panel in high performance applications where the fastener element **20** is formed of a high strength hardened carbon steel as required for such applications. In a preferred embodiment, the axial length "L" of the tubular barrel is less than 60% of the outer diameter "D" or more preferably about 55%. The

self-riveting male fastener **20** is preferably formed of a high strength carbon steel having a hardness greater than **30** Rockwell C as discussed further below.

[00024] In such high performance applications, it is also desirable to provide antirotation means or sufficient torque resistance to prevent rotation of the fastener element **20** relative to a panel following installation of the fastener element **20** in a panel. In the disclosed embodiment of the self-riveting male fastener **20**, the outer surface of the radial flange portion **26** includes a plurality of equally circumferentially spaced radial teeth **44** each having generally radially extending planar side surfaces **48**, a cylindrical end surface **50** and planar surfaces **52** between the radial teeth **44** as best shown in Figures 1 and 4. In a preferred embodiment, the planar generally radially extending side surfaces **48** extend generally perpendicular to a circumference "C" of the generally cylindrical radial flange portion **26** providing maximum torque resistance when the radial flange portion **26** is driven into a panel as described below. In the disclosed embodiment, the generally radially extending planar side surfaces **48** of adjacent radial teeth **44** are parallel for ease of manufacture. However, as discussed further below, the radial teeth may have other configurations or other antirotation means may be provided.

[00025] As described above, the self-riveting male fastener **20** may be installed in a panel in a die press (not shown), wherein the lower die shoe or die platen includes a die member or die button **54** as shown in Figures 5 and 6 and the upper die member includes an installation head (not shown) having a reciprocating plunger described below with regard to Figures 7 to 9. The die button **54** shown in Figures 5 and 6 includes a planar panel supporting surface **56** surrounding a die cavity **58** as best shown in Figure 6. The die cavity **58** includes an annular arcuate concave die surface **60** which extends to adjacent the planar annular outer surface **56** and a central

die post **62** preferably having a planar end surface **64** and an axial opening **66** to vent air from the die cavity **58** during installation of the self-riveting male fastener **20** as shown in Figures 7 to 9. The annular concave arcuate surface **60** preferably blends with the planar panel-supporting surface with a slight radius, as shown.

5           **[00026]**       As disclosed further in the above referenced U.S. Patent No. 4,915,558, the upper die shoe or die platen of a die press (not shown) includes an installation head (not shown) which receives the male fastener elements **20** and a reciprocating plunger **68** installs a male fastener in a panel with each stroke of the die press. The plunger **68** includes an axial opening **71** which receives the shank portion  
10   **22** of the male fastener element **20** and an annular end face **74** which is driven against the radial flange portion **26** as shown in Figure 7. The panel **70** is supported on the annular panel supporting surface **56** in the lower guide shoe (not shown) including a panel preformed opening **72** having an internal diameter generally equal to or slightly greater than the diameter of the outer cylindrical surface **34** of the tubular barrel  
15   portion **28**. The plunger **68** aligns the tubular barrel portion **28** with the panel opening **72** and the panel opening **72** is coaxially aligned with the die cavity **58**, such that the chamfered distal end surface **38** is coaxially aligned with an inner surface of the annular arcuate concave die surface **60**. The annular end face **74** of the plunger **68** then drives the distal end **40** of the tubular barrel portion **28** through the panel opening  
20   **72** as shown in Figure 7. The plunger **68** then drives the distal end **40** of the tubular barrel portion **28** against the annular arcuate concave die surface **60**, deforming the distal end **40** of the tubular barrel portion radially outwardly in the annular arcuate concave die surface **60** as shown in Figure 8.

**[00027]**       Figure 9 illustrates the final step in forming the self-riveting  
25   male fastener and panel assembly and Figure 10 is an enlarged view of the male

fastener and panel assembly. As shown in Figure 9, the distal end 40 of the tubular barrel portion is deformed radially outwardly into an L-shape, including generally radially outwardly extending portion 74 spaced from the radial flange portion 26 and a tubular portion 28A, including an arcuate surface 76 extending from the distal end 40 to the bottom wall 32 of the barrel portion 28 which smoothly blends with the L-shaped panel portion. As the annular surface 42 of the radial flange portion 26 is driven into the panel portion 70 surrounding the preformed opening 72, a portion of the panel is deformed into the die cavity 58 (see Figure 6) into an L-shape, including a portion extending perpendicular to the planar panel and a generally radially inwardly directed portion 78 deformed between the generally radially outwardly directed barrel portion 74 and the annular surface 42 of the radial flange portion 76. The L-shaped portion 78 further includes an inner surface 80 which is deformed radially inwardly against the cylindrical outer surface 50 of the radial teeth and against the planar surfaces 52 between the teeth preventing rotation of the self-riveting fastening element 20 and the panel 70. As best shown in Figure 10, the radially inwardly directed panel portion 78 is deformed between the annular surface 42 of the radial flange 26 and the radially outwardly projecting distal end portion 74, such that the thickness of the radial portion 78 is about one half the thickness of the original panel 70 and the inner panel surface 80 is in substantially full face to face contact with the outer surface of the radial flange portion 26.

[00028] Testing of the male fastener and panel assembly shown in Figure 10 results in a very secure installation and avoids cracking of the barrel 28 even where the self-riveting male fastener element 20 is formed of a high strength carbon steel which has been heat treated to a hardness of 30 Rockwell C or greater, making this installation suitable for high performance applications including, for

example, automotive seat restraining studs and safety related applications, such as seat and seat belt retainers, passive restraints and the like. A suitable high strength carbon steel is SAE 1038 carbon steel which is heat treated to Class 10.9, resulting in a hardness of between 30 and 40 Rockwell C. The barrel portion of a conventional  
5 10 mm self-piercing stud as disclosed in US Patent No. 5,092,724 has an axial length of 11 mm and an outside diameter of 14 mm and an inside diameter of 10.3 mm, with a wall thickness 1.85 mm, such that the volume of the barrel portion is 1,564.9 mm<sup>3</sup>. However, if the self-piercing stud shown in US Patent No. 5,092,724 is heat treated to about 30 Rockwell C, the barrel portion will crack if installed as disclosed in this  
10 patent. In comparison, the barrel portion of a 10 mm stud as disclosed in this application has an axial length of 6.8 mm, an outside diameter of 12.55 mm and an inside diameter of 8.85 mm, resulting in a volume of 834.8 mm<sup>3</sup> and does not result in cracking of the barrel when installed as shown in Figure 10. Testing indicates that the shank portion **22** will fracture before the stud is either rotated in the panel or pulled  
15 out of the panel following installation. The male fastener **20** may also be installed in relatively thick panels, such as steel panels having a thickness of 3.5 mm. Thus, the self-riveting fastening element and panel assembly of this invention may be utilized in high performance applications and solves the problems associated with the prior fastener systems for such applications.

20           **[00029]**       As will be understood by those skilled in this art, various modifications may be made to the self-riveting male fastener **20** and fastener and panel assembly shown in Figure 10 within the purview of the appended claims. For example, the shank portion **22** may be unthreaded for receipt of a thread-forming female fastener, such as a nut or may have other configurations, including an integral  
25 ball for utilization as a ball joint. Further, other antirotation means may be utilized,

such as the scalloped configuration shown in U.S. Patent No. 6,122,816, pockets or projections may also be provided in the surface **42** of the flange portion as is known in this art. However, equally circumferentially spaced radial teeth **44** having generally radially extending planar side surfaces provides superior torque resistance. Having  
5 described a preferred embodiment of the self-riveting male fastener and male fastener and panel assembly of this invention, the invention is now claimed as follows.